

**FEDERAL HIGHWAY
ADMINISTRATION
EASTERN FEDERAL
LANDS HIGHWAY
DIVISION**

**SOILS AND FOUNDATION
REPORT – ADDENDUM**

FINAL 100% SUBMITTAL

**CRAGGY GARDENS SLOPE
INVESTIGATION**

REHABILITATION OF PARK ROADS
FOR BLUE RIDGE PARKWAY
YANCEY AND BUNCOMBE
COUNTIES, NORTH CAROLINA

PRA-BLRI 2P14
CONTRACT NO. DTFH71-02-D-00004
TASK ORDER 0003

Pete Zimmerman
Geotechnical Engineer

Paul Booth, PE
Geotechnical Manager

Brian Whitaker, PE
Project Manager

Soils and Foundation Report – Addendum

Craggy Gardens Slope Investigation

Rehabilitation of Park Roads for Blue Ridge Parkway Yancey and Buncombe Counties, North Carolina

PRA-BLRI 2P14
Contract No. DTFH71-02-D-00004
Task Order 0003
Modification No. 003

Prepared for:
Federal Highway Administration
Eastern Federal Lands Highway Division

Prepared by:
ARCADIS G&M, Inc.
1210 Premier Drive
Suite 200
Chattanooga
Tennessee 37421
Tel 423 756 7193
Fax 423 756 7197

Our Ref.:
CT052885.0002.00015

Date:
September 2006

*This document is intended only for the use of
the individual or entity for which it was
prepared and may contain information that is
privileged, confidential, and exempt from
disclosure under applicable law. Any
dissemination, distribution, or copying of this
document is strictly prohibited.*

Table of Contents

Background	1
Project Area	1
Overview	1
Regional Geology	2
Craggy Gardens Slope Investigation	3
General	3
Subsurface Investigation	3
Analyses	3
Recommendations	4
References	5

Table of Contents

Tables

- 1 Stabilization Alternatives

Figures

- 1 Slope Investigation – Blue Ridge Parkway Project Location Map
- 2 Slope Investigation at Craggy Gardens Picnic Access Area Boring Location Plan
- 3 Slope Investigation at Craggy Gardens Picnic Area Sections A and B
- 4 Craggy Gardens Picnic Area Seepage Collector Trenches

Appendices

- A Figures
- B Photographs
- C S&ME Inc. Report Documenting Results of the Subsurface Investigation
- D Stability and Seepage Analysis Calculations

Background

The Blue Ridge Parkway is a 469-mile scenic corridor that connects Shenandoah Valley in Virginia to the Great Smoky Mountains National Park in North Carolina. Adjacent to the parkway, which ranges in elevation from 649 feet to 6,047 feet, are recreational areas that include picnic facilities, hiking trails, visitor centers, overlooks, and campgrounds. The Blue Ridge Parkway, conceived as a Depression-relief project in the 1930s, took more than 50 years to construct.

The pavement along Blue Ridge Parkway and adjacent access roads and pull-offs is in various stages of deterioration and in need of rehabilitation. Area features such as asphalt paths, granite curbs, rubble and masonry walls and steps are also in need of repair. Under initial Task Order No. 0003, ARCADIS was authorized to investigate Section 2P of the Blue Ridge Parkway and develop plans and specifications to rehabilitate this section of the parkway. Section 2P consists of the rehabilitation of the parkway pavement between Milepost 359.8 at the Balsam Gap Overlook and Milepost 375.3. Also included is the reconstruction, replacement, or rehabilitation of ditches, pipes, walls, sidewalks, and curbs. A soils and foundation report has been previously submitted documenting results of subsurface and pavement investigations along Section 2P.

Modification No. 0003 to the Task Order was later issued to cover the investigation and evaluation of an unstable slope located adjacent to the Craggy Gardens Picnic Area access road. The purpose of this addendum to the Soils and Foundation Report is to document the findings of the investigation of the unstable slope and present recommendations for stabilizing the slope.

Project Area

Overview

Within Section 2P, there are six parking and pull-off areas, one picnic parking area with a 1.2-mile access road referred to as Craggy Gardens Access Road, a visitor's center parking area located at approximately Mile 364.6, and three tunnels that have already been reconditioned. Within the project limits, the average roadway width is 22 feet and the length is approximately 15.5 miles. Appendix A contains all the figures for this report. Figure 1 presents a Project Location Map.

Regional Geology

Section 2P lies within the Blue Ridge physiographic province east of the French Broad River and west of Mount Mitchell. The Blue Ridge physiographic province resulted from a series of mountain building (orogeny) and metamorphic events beginning with the Grenville Orogeny, 1,000 million years ago (mya), and culminating with the Alleghanian Orogeny (300-245 mya) (Carter, Merschat et al. 2001). Cycles of continental collision and rifting resulted in a structurally complex group of ultramafic and mafic rocks, and high-grade metamorphic rocks.

The geology of the area is predominantly the Ashe Metamorphic Suite (AMS) containing a series of layered mica gneiss, quartz-feldspar gneiss, mica schist, pegmatite, amphibolites, and eclogites. The gneiss and schist are interpreted as metamorphosed conglomerates and sandstones. The amphibolites are interpreted as metamorphosed basalt (volcanic rock) (Hatcher and Goldberg, 1991). The eclogites are interpreted as metamorphosed rocks that were part of an accretionary wedge of a convergent continent (Willard and Adams 1994). The schist, gneiss, and amphibolites are the result of low-to-moderate pressure and moderate-to-high temperature conditions. The eclogites were exposed to high pressure and moderate-to-high temperature conditions. The above pressure – temperature environments are consistent with continental collision events.

The AMS is in the hanging wall (the thrust sheet above the plane of the fault) of the Holland Mountain Fault (HMF), which trends northeast-southwest in this area and dips to the southeast. Thrust faults are low angle (less than 30 degrees) reverse faults. These faults are shown as single traces on geologic maps; however, in the field they occur as a series of faults and splays rather than a single expression. Within the hanging wall of the HMF is the Burnsville Fault, which roughly parallels (separation approximately 4 miles) the HMF in this study area. The Burnsville Fault was thought to be a thrust fault as shown on the geologic map. Recently the fault has been reinterpreted as a dextral strike-slip shear zone, which is the boundary between the Pumpkin Patch thrust sheet to the west and Spruce Pine thrust sheet to the east (Stewart, Trupe et al. 1997). The studied section lies within the Spruce Pine thrust sheet southeast of the Burnsville Fault approximately 20 miles south of Burnsville, North Carolina.

Craggy Gardens Slope Investigation

General

ARCADIS was tasked with investigating a potentially unstable slope adjacent the access road to the Craggy Gardens Picnic Area, at Milepost 367.6. This investigation was considered necessary after shear cracks were observed in the slope. Photographs 1 and 2 show the slope and general area of concern. Photographs 3 and 4 show examples of the shear cracks at the ground surface. All photographs are provided in Appendix B.

Subsurface Investigation

The first phase of the slide investigation consisted of a subsurface investigation. The subsurface investigation included drilling five borings to depths ranging from 26 to 50 feet. Boring locations are indicated on Figure 2. Borings were advanced by the Standard Penetration Test (ASTM D-1586) method and augering. Representative soil samples were collected for index type testing. Groundwater levels were noted initially after completion of each boring and, when possible, a minimum 24 hours after completion of drilling. A report by S&ME Inc. documenting results of the subsurface investigation is provided in Appendix C.

Analyses

Results of the field investigation were used to develop a typical geologic section through the unstable slope. This is reflected on Figure 3. It is noted that groundwater was encountered within a few feet of the surface within the zone that shear cracking was observed. See borings B-37, 39, and 40. The shear cracking occurred during a period of high rainfall, and high groundwater level is considered the probable cause of the slope instability. Stability analyses were conducted for the typical section using the computer program UTEXAS4. The typical section included an assumed groundwater level at the ground surface. Through an iterative process and based on the location of shear cracks, shear strengths were determined that produced a critical factor of safety of approximately 1.0 for the typical section. This is represented by the Case 1 analysis presented on Figure 3.

Several alternatives were then considered as possible means for stabilizing the slope. The options considered and their approximate estimated costs are summarized in Table 1.

Soils and Foundation Report - Addendum

Blue Ridge Parkway
Rehabilitation

TABLE 1
Stabilization Alternatives

Option	Estimated Cost
Rock Buttress	\$77,800
Stone Masonry Wall	\$78,900
Collector Trenches	\$38,000
Sheet Piling	\$69,500

Based on the cost estimates, the use of collector trenches to lower the groundwater was considered the preferred option, subject to satisfactory results from slope stability analyses.

Slope stability analyses were again conducted with the same soil shear strengths determined in stability analysis Case 1 and revised groundwater conditions based on installing the collector trenches. This analysis is identified as Case 2 on Figure 3. The Case 2 analysis produced a critical factor of safety of 1.84, which is considered adequate. A seepage analysis was also conducted based on installation of the collector trenches. Calculations are included in Appendix D.

Recommendations

An investigation and analyses have been conducted for the section of unstable slope near the Craggy Gardens Picnic Area access road. Several alternatives were considered for stabilizing the slope. Based on the results, installation of collector trenches as shown on Figure 4 is recommended. The collector trenches will incorporate the Multi-flow drainage system as requested by the NPS and FHWA.

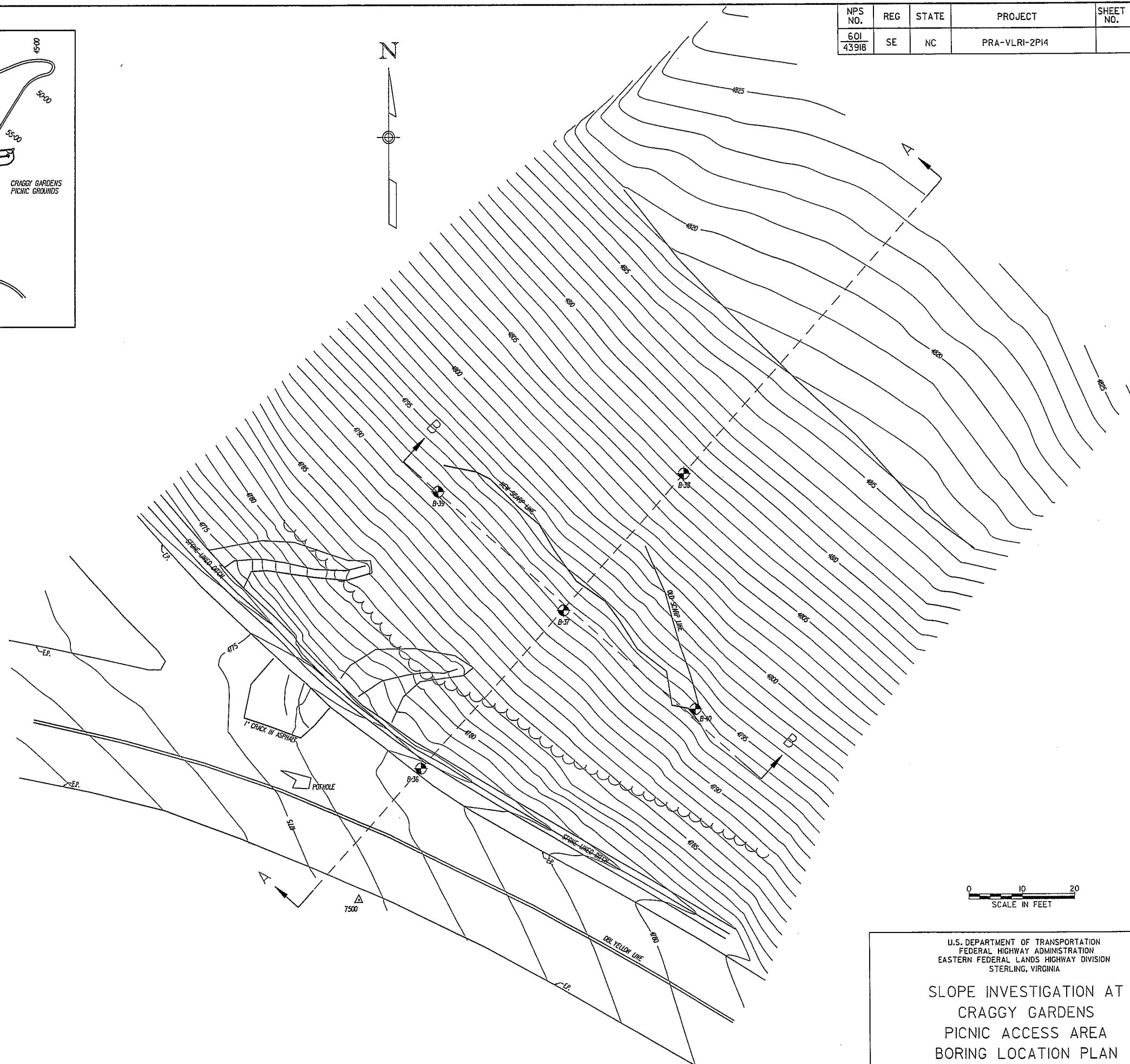
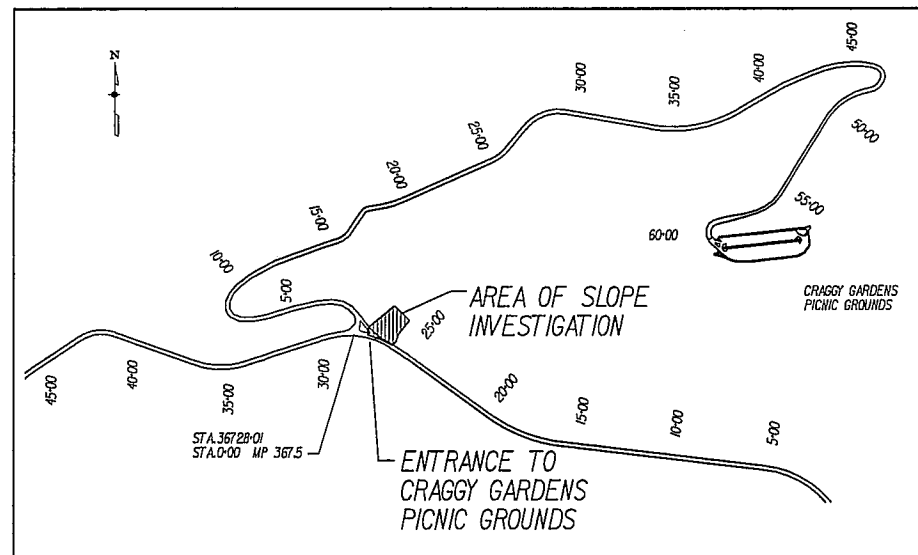
References

1. Carter, Mark W., Carl E. Merschat, William F. Wilson. "A Geologic Adventure along the Blue Ridge Parkway in North Carolina," Bulletin 98, Raleigh, North Carolina. North Carolina Geological Survey. 3-4 of 60 p. 2001.
2. Hatcher, Robert D. Jr. and Steven A. Goldberg. *The Blue Ridge Geologic Province. Geology of the Carolinas: Carolina Geological Society Fiftieth Anniversary Volume*. The University of Tennessee Press. 22-3 of 406 p. 1991.
3. Willard, R.A., and Mark G. Adams. "Newly Discovered Eclogite in the Southern Appalachian Orogen, Northwestern North Carolina." *Earth and Planetary Science Letters* 123, 61-70. 1994.
4. Stewart, Kevin G., Charles H. Trupe, and Mark G. Adams. *Paleozoic Structure, Metamorphism, and Tectonics of the Blue Ridge of Western North Carolina*, Carolina Geological Society 1997 Field Trip Guidebook. <http://carolinageologicalsociety.org/gb%201997.pdf>. 23 of 107 p. 1997.

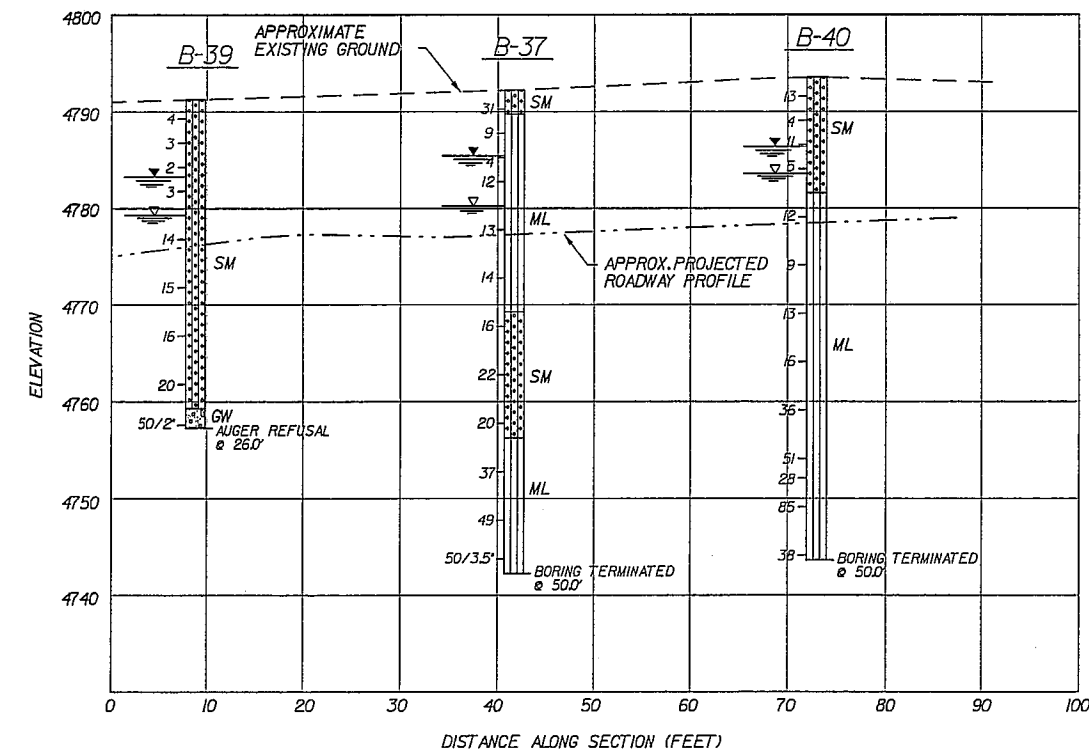
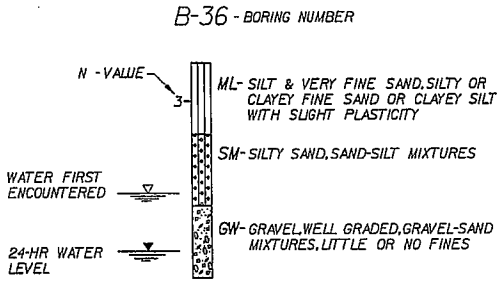
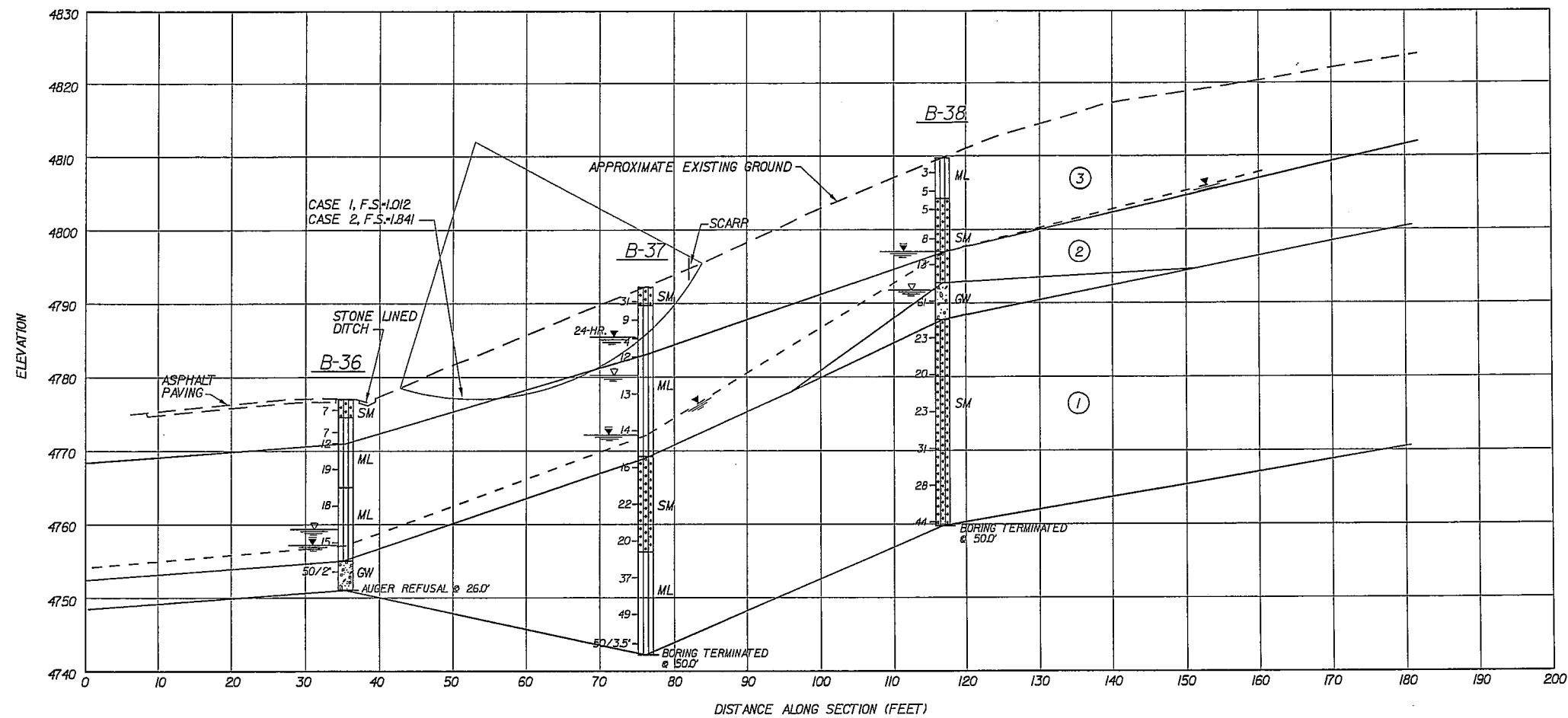
Appendix A

Figures

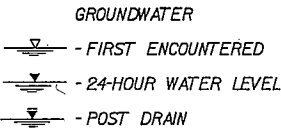
NPS NO.	REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
601 43918	SE	NC	PRA-VLRI-2P14		



NPS NO.	REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
601 43918	SE	NC	PRA-VLRI-2P14		



SOIL PARAMETERS				
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	
			COHESION	FRICTION ANGLE
1	SILTY SAND	120	0	33
2	SILT (ML)	110	100	30
3	ML/SM (LOW N-VALUE)	110	100	26

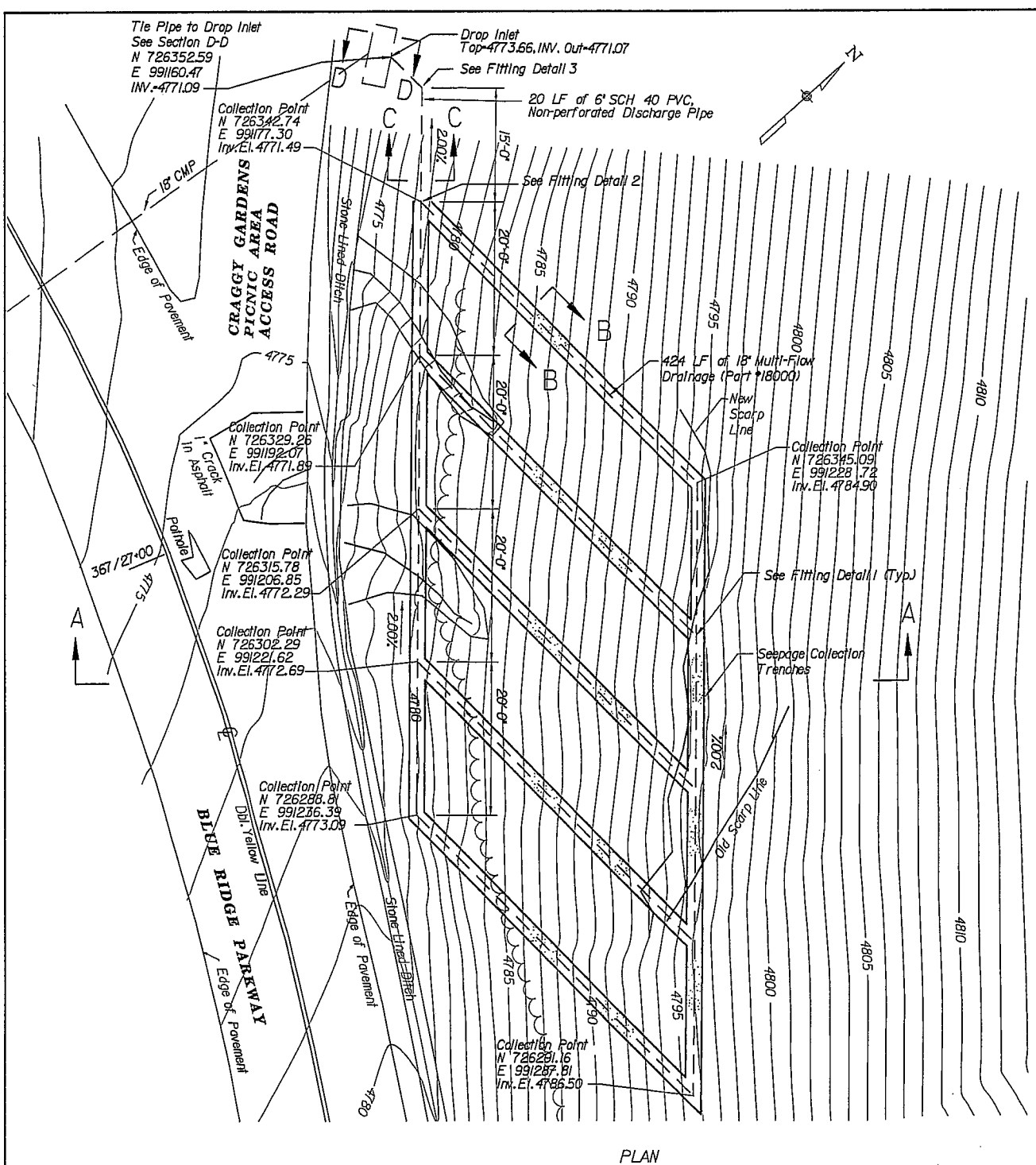


STABILITY ANALYSIS:
CASE 1 - EXISTING CONDITION
CASE 2 - POST DRAIN

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

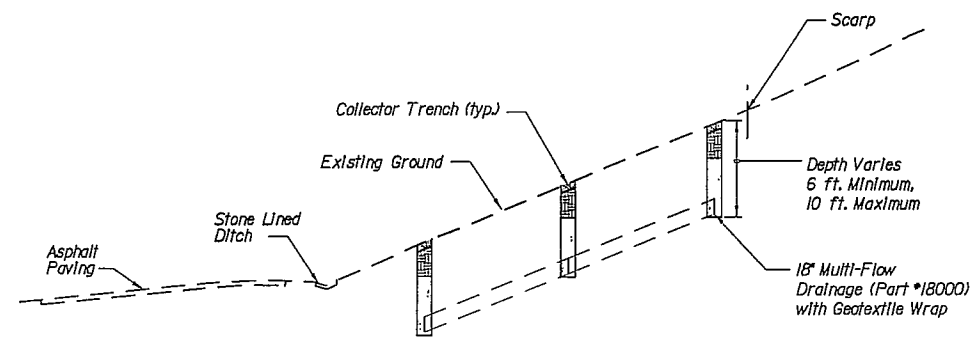
SLOPE INVESTIGATION AT
CRAGGY GARDENS
PICNIC ACCESS AREA
SECTIONS A AND B
FIG. 3

NPS NO.	REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
601 43918	SE	NC	PRA-BLRI-2P14		

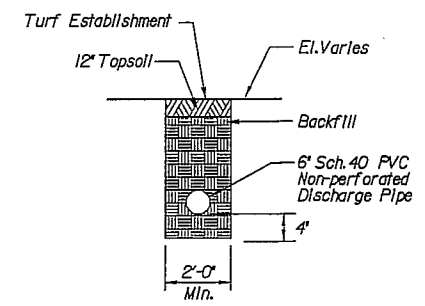


PLAN

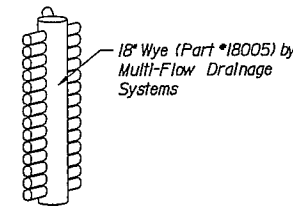
* See Craggy Gardens Picnic Area Access Road Intersection Plan for control point locations and descriptions.



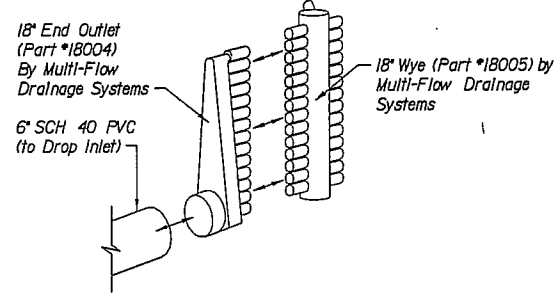
TYPICAL SECTION A-A
Not to Scale



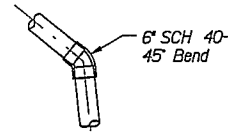
TYPICAL OUTLET PIPE TRENCH DETAIL
(SECTION C-C)
Not to Scale



FITTING DETAIL 1
Not to Scale



FITTING DETAIL 2
Not to Scale



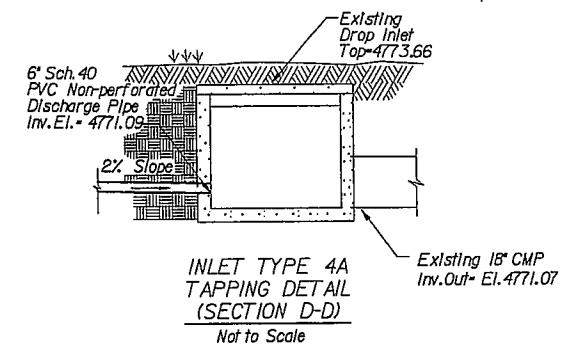
FITTING DETAIL 3
Not to Scale

Note:

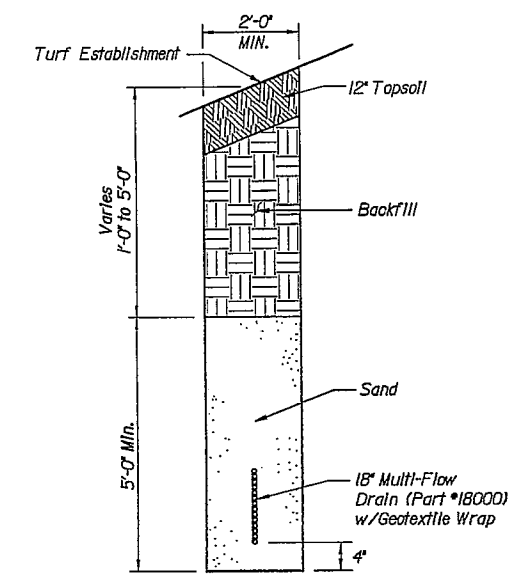
The contractor shall use the following construction sequence:

1. Place silt fence and inlet protection at construction area (see Erosion and Sediment Control Narrative sheet).
2. National Park Service or Blue Ridge Parkway Resource Division personnel may harvest existing vegetation prior to beginning construction.
3. Clear and grub area that will be disturbed during underdrain construction. The cleared area includes the width of the trench as well as a work area 10 feet in width along the length of the proposed drain. Remove the top 12 inches of soil from the cleared areas. Conserve the top 12 inches of soil and stockpile it separately from the excavated trench soil.
4. Revegetate the cleared and grubbed area with an appropriate seed mix (annual rye or winter rye depending on the time of year).
5. Construct the 6" PVC discharge pipe and the 80-foot of collector trench with Multi-flow Drainage System located on the most downhill portion of the site. A maximum of 25 feet of trench shall be open at any given time. The trench shall be filled with the granular backfill, backfill, and topsoil before excavation is begun on the next 25 feet of trench.
6. Construct the collector drains that run uphill at a 45-degree angle from the bottom collector. One trench shall be excavated and the drain completed before opening the next collector trench.
7. Construct the top collector drain. A maximum of 25 feet of trench shall be open at any given time. The trench shall be filled with the granular backfill, backfill, and topsoil before the next 25 feet of trench is excavated.
8. Place the conserved 12 inches of topsoil on areas that were previously cleared.
9. Establish turf on the disturbed areas. National Park Service or Blue Ridge Parkway Resource Division personnel may plant appropriate supplemental vegetation.
10. Remove silt fence and inlet protection after turf has been established.

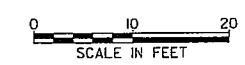
Note: It is recommended that construction occur during the driest season possible. It is acceptable to construct this drainage system when the ground surface is frozen.



INLET TYPE 4A
TAPPING DETAIL
(SECTION D-D)
Not to Scale



TYPICAL COLLECTOR TRENCH DETAIL
(SECTION B-B)
Not to Scale



U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
EASTERN FEDERAL LANDS HIGHWAY DIVISION
STERLING, VIRGINIA

Craggy Gardens
Picnic Access Area
Seepage Collector Trenches

Appendix B

Photographs



Photo 1. Mid-slope facing
toward Craggy Gardens Access
Road.



Photo 2. Facing slope from Blue
Ridge Parkway.



Photo 3. Shear cracks on slope.



Photo 4. Shear cracks on slope.

Appendix C

S&ME Inc. Report Documenting
Results of the Subsurface
Investigation

**SUBSURFACE EXPLORATION
REPORT**

**BLUE RIDGE PARKWAY
CRAGGY GARDENS SLIDE
ASHEVILLE, NORTH CAROLINA
S&ME PROJECT NO. 1411-05-098**

Prepared For:

**ARCADIS, INC
1210 PREMIER DRIVE
SUITE 200
CHATTANOOGA, TENNESSEE 37421**

Prepared By:

**S&ME, Inc.
44 Buck Shoals Road, Suite C-3
Arden, North Carolina 28704**

May 31, 2005



May 31, 2005

Arcadis, Inc.
1210 Premier Drive
Suite 200
Chattanooga, Tennessee 37421

Attention: Mr. Bob Chamlee

Reference: **SUBSURFACE EXPLORATION REPORT**
Blue Ridge Parkway at Craggy Gardens Picnic Area
Asheville, North Carolina
S&ME Project No. 1411-05-098

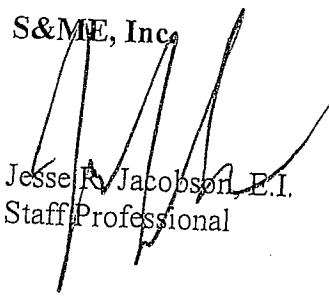
Dear Mr. Chamlee:

S&ME, Inc. has completed the authorized subsurface exploration program for the cut slope at the Craggy Gardens Picnic Area near Asheville, North Carolina. The exploration was performed in accordance with our Proposal No. ENG-004-05 dated January 5, 2005. This report presents a brief description of the existing slope and data from our subsurface exploration program.

S&ME appreciates the opportunity to provide you with our services. Should you have any questions regarding the information presented in this report, or if we may be of any further assistance, please contact us at your convenience.

Sincerely,

S&ME, Inc.


Jesse R. Jacobson, E.I.
Staff Professional

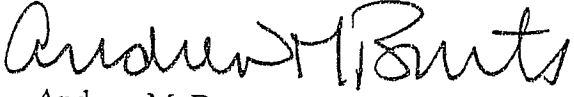

Andrew M. Burton, P.E.
Branch Manager

TABLE OF CONTENTS

	<u>PAGE</u>
EXECUTIVE SUMMARY.....	1
1.0 PROJECT INFORMATION	2
2.0 EXPLORATION AND TESTING PROGRAM	3
3.0 SUBSURFACE CONDITIONS	4
3.1 CULTIVATED SOIL	4
3.2 ALLUVIUM	4
3.3 RESIDUUM	5
3.4 GROUNDWATER.....	5
4.0 LABORATORY TEST RESULTS.....	6

APPENDIX

Boring Logs

Laboratory Test Results

1.0 PROJECT INFORMATION

A cut slope on the north side of the Blue Ridge Parkway at milepost 367.6 has experienced downward movement. The slide area is above the road and parallels the Parkway at the entrance to the Craggy Garden Picnic Area entrance road. The slide area is roughly 80 feet long and the highest series of tension cracks are roughly 30 feet above the road. The tension cracks had been marked with red ribbon by others and were four to six inches wide and less than a foot deep. The slope inclination appears to range from 2.5:1 to 3:1 (Horizontal:Vertical). There also appears to be a slight bulge in the pavement at the toe of slope.

2.0 EXPLORATION AND TESTING PROGRAM

2.1 FIELD TESTING

Five soil test borings were drilled in the area of the slope. The boring locations were established in the field by Arcadis. Ground surface elevations of the borings were unknown at the time of our exploration.

The soil test borings were extended to depths ranging from 26 to 50 feet. Standard Penetration Tests (ASTM D-1586) were performed, and representative split-spoon soil samples were obtained at each soil test boring location. Standard penetration testing is used to determine soil relative density and consistency information. Split-spoon samples are obtained to visually classify representative soil samples. Standard penetration tests were performed, and split-spoon samples were obtained at 2.5-foot intervals for the first ten feet of depth below the existing grade, and at 5.0-foot depth intervals thereafter. Groundwater levels were recorded at the termination of drilling and at a minimum of 24 hours after the termination of drilling. Bulk samples were collected from each of the borings. No rock coring was performed due to the very deep auger refusals.

2.2 LABORATORY TESTING

The bulk and split-spoon samples were transported to our laboratory where they were visually and manually classified by our Geotechnical Engineering staff. The visual and manual classification of the soils was estimated, based on the Unified Soil Classification System (USCS) and our experience. Representative soil samples were subjected to the following laboratory tests: Natural Moisture Contents, Atterberg Limits and Grain Size Distribution.

Testing was performed in general accordance with ASTM or other applicable testing standards. The results are presented on data sheets in Appendix C.

3.0 SUBSURFACE CONDITIONS

The subsurface conditions described herein have been generalized. Detailed data at each soil test boring location can be obtained from the individual Boring Logs provided in the Appendix of this report.

3.1 TOPSOIL

Because the site had been previously stripped in preparation for drilling activities, topsoil was not encountered in the boring locations.

3.2 COLLUVIUM

In Borings B-3 and B-4, a layer of colluvium was encountered to depths of about 22 and 6 feet, respectively. Colluvium is soil transported to its current location by gravity (i.e. landslides in the recent or geologic past). The colluvium consisted of sandy silts, silty sands and weathered rock fragments. The SPT resistance values ranged from 3 to 13 blows per foot (bpf) in the sand and weathered rock fragments, indicating a very loose to medium dense relative density, and from 3 to 5 bpf in the silts, indicating a soft to firm consistency. These values were likely amplified by the presence of rock fragments.

3.3 RESIDUUM

Soil interpreted as residuum was encountered at the ground surface in Borings B-1, B-2 and B-5, and below the colluvium in Borings B-3 and B-4 to depths ranging from 22 to 50 feet. Residuum is soil weathered in place from the underlying parent bedrock. The residuum typically consisted of sandy silt and silty fine sand. The residuum has varying mica and moisture content. SPT resistance values ranged from 2 to 23 blows per foot in the sands, indicating a very loose to medium dense relative density, and from 7 to over 50 bpf in the

silts, indicating a firm to very hard consistency. Borings B-3 and B-5 were terminated in the residual soil at a depth of 50 feet.

3.4 PARTIALLY WEATHERED ROCK

Partially weathered rock (PWR) was encountered directly below the residuum in Borings B-1, B-2 and B-4. Partially weathered rock is a transitional material from very hard residual soil to rock with a standard penetration resistance of at least 50 blows per 6 inches. Boring B-2 was terminated in the PWR at a depth of 50 feet.

3.5 REFUSAL MATERIAL

Refusal to auger advancement was encountered in Borings B-1 and B-4 at a depth of 26 and 34 feet, respectively. The refusal material could consist of a boulder, rock lens, or relatively massive rock within the soil mantle, or potentially the surface of continuous bedrock.

3.6 GROUNDWATER

Groundwater was observed in each boring at depths ranging from 10 to 18 feet just after termination of the boring. However, 24-hour water level readings indicated depths ranging from 7 to 8 feet. Please remember that groundwater elevations will fluctuate due to seasonal and climatic changes, and may fluctuate due to construction activity in the area.

4.0 LABORATORY TEST RESULTS

The following table presents a summary of the results from the laboratory testing program. Testing was performed in general accordance with ASTM or other applicable testing standards. The results are presented on data sheets in Appendix C.

BORING NO.	DEPTH (feet)		NAT. MOIST (%)	GRAIN SIZE DISTRIBUTION		ATTERBERG LIMITS	
				Sand & Gravel	Fines	LL	PI
	From	To		(%)	(%)		
B-1	1.0	2.5		71.3	28.6		
B-1	9.0	10.5	26.8				
B-2	2.0	3.5	17.9				
B-2	6.0	7.5	35.9	67.2	32.8	32	NP*
B-3	4.0	5.5	49.4			46	NP*
B-3	7.0	8.5	23.1				
B-3	14.0	15.5	8.3				
B-4	3.5	5.0	32.5	80.2	19.7	31	NP*
B-4	9.0	10.5	29.	92.0	7.0		
B-4	14.0	15.5	28.1				
B-5	6.0	7.5	21.3	84.8	15.2		
B-5	14.0	15.5	35.1				
B-5	19.0	20.5	33.3				

*NP = Non plastic

5.0 LIMITATIONS OF REPORT

This report has been prepared in accordance with generally accepted geotechnical engineering practice. The data contained herein are based on the applicable standards of the profession at the time this report was prepared. No other warranty, expressed or implied, is made.

The evaluations submitted in this report are based, in part, upon the data obtained from the subsurface exploration. The nature and extent of variations in subsurface conditions will not become evident until construction. If variations appear evident, it will be necessary to re-evaluate the data contained in this report.

LEGEND TO SOIL CLASSIFICATION AND SYMBOLS

SOIL TYPES

(Shown in Graphic Log)



Fill



Asphalt



Concrete



Topsoil



Gravel



Sand



Silt



Clay



Organic



Silty Sand



Clayey Sand



Sandy Silt



Clayey Silt



Sandy Clay



Silty Clay



Partially Weathered Rock



Cored Rock

WATER LEVELS

(Shown in Water Level Column)

▽ = Water Level At Termination of Boring

▽ = Water Level Taken After 24 Hours

◀ = Loss of Drilling Water

HC = Hole Cave

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY

Very Soft

Soft

Firm

Stiff

Very Stiff

Hard

Very Hard

STD. PENETRATION RESISTANCE BLOWS/FOOT

0 to 2

3 to 4

5 to 8

9 to 15

16 to 30

31 to 50

Over 50

RELATIVE DENSITY OF COHESIONLESS SOILS

RELATIVE DENSITY

Very Loose

Loose

Medium Dense

Dense

Very Dense

STD. PENETRATION RESISTANCE BLOWS/FOOT

0 to 4

5 to 10

11 to 30

31 to 50

Over 50

SAMPLER TYPES

(Shown in Samples Column)



Shelby Tube



Split Spoon



Rock Core



No Recovery

TERMS

Standard Penetration Resistance - The Number of Blows of 140 lb. Hammer Falling 30 in. Required to Drive 1.4 in. I.D. Split Spoon Sampler 1 Foot. As Specified in ASTM D-1586.

REC - Total Length of Rock Recovered in the Core Barrel Divided by the Total Length of the Core Run Times 100%.

RQD - Total Length of Sound Rock Segments Recovered that are Longer Than or Equal to 4" (mechanical breaks excluded) Divided by the Total Length of the Core Run Times 100%.



DATE DRILLED: 4/19/05

ELEVATION:

DRILLING METHOD: 2 1/4" H.S.A.

BORING DEPTH: 26.0

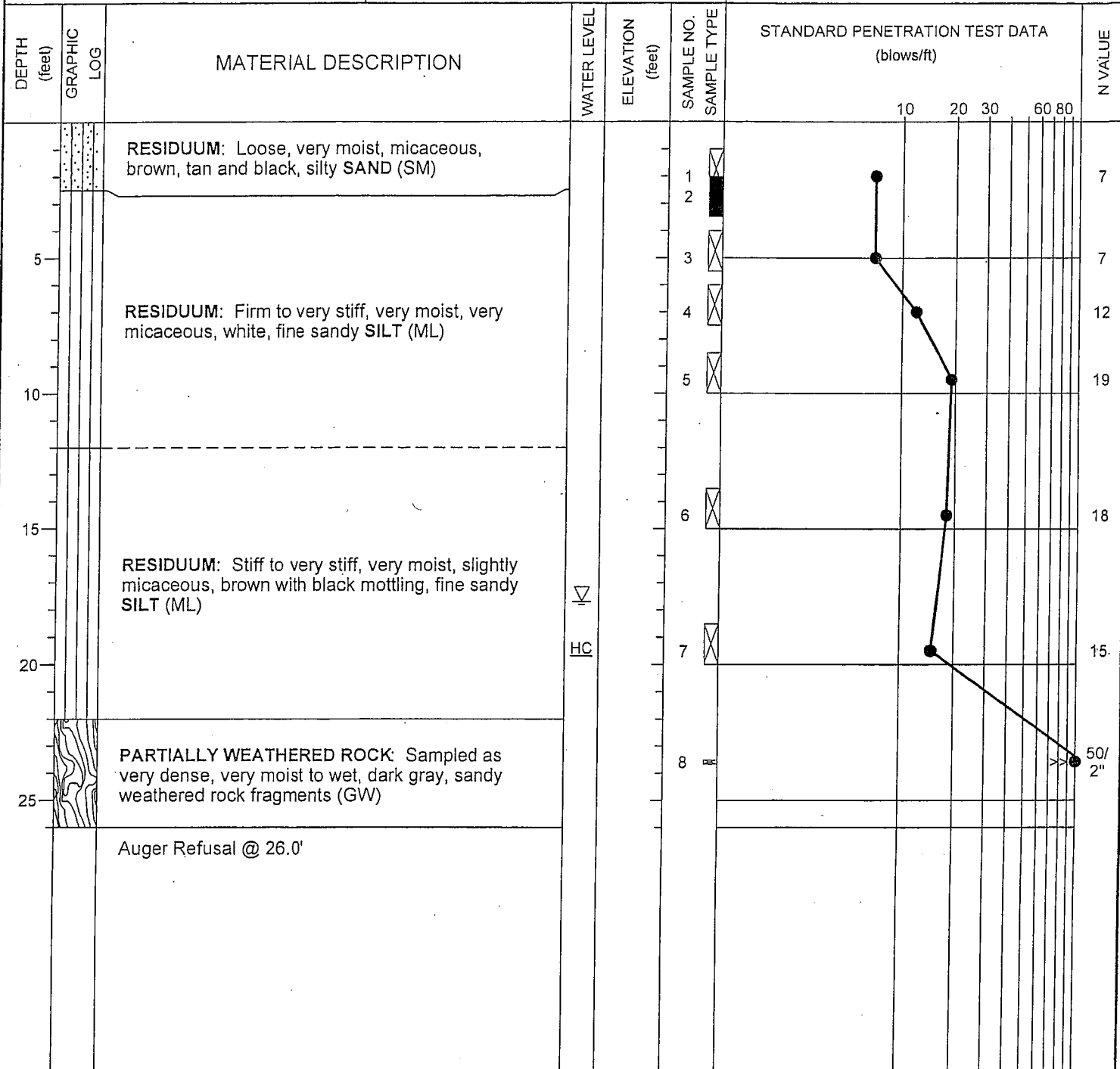
LOGGED BY: J. JACOBSON

WATER LEVEL: 17.7' @ TOB

DRILLER:

DRILL RIG: Mobile B-56

NOTES:



NOTES:

- THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.
- BORING, SAMPLING AND PENETRATION TEST DATA IN GENERAL ACCORDANCE WITH ASTM D-1586.
- STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.
- WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.



S&ME

ENGINEERING • TESTING
ENVIRONMENTAL SERVICES

DATE DRILLED: 4/18/05	ELEVATION:	NOTES: CUT 5 FEET
DRILLING METHOD: 2 1/4" H.S.A.	BORING DEPTH: 50.0	
LOGGED BY: J. JACOBSON	WATER LEVEL: 7.0' @ 24 HOURS	
DRILLER:	DRILL RIG: Mobile B-56	

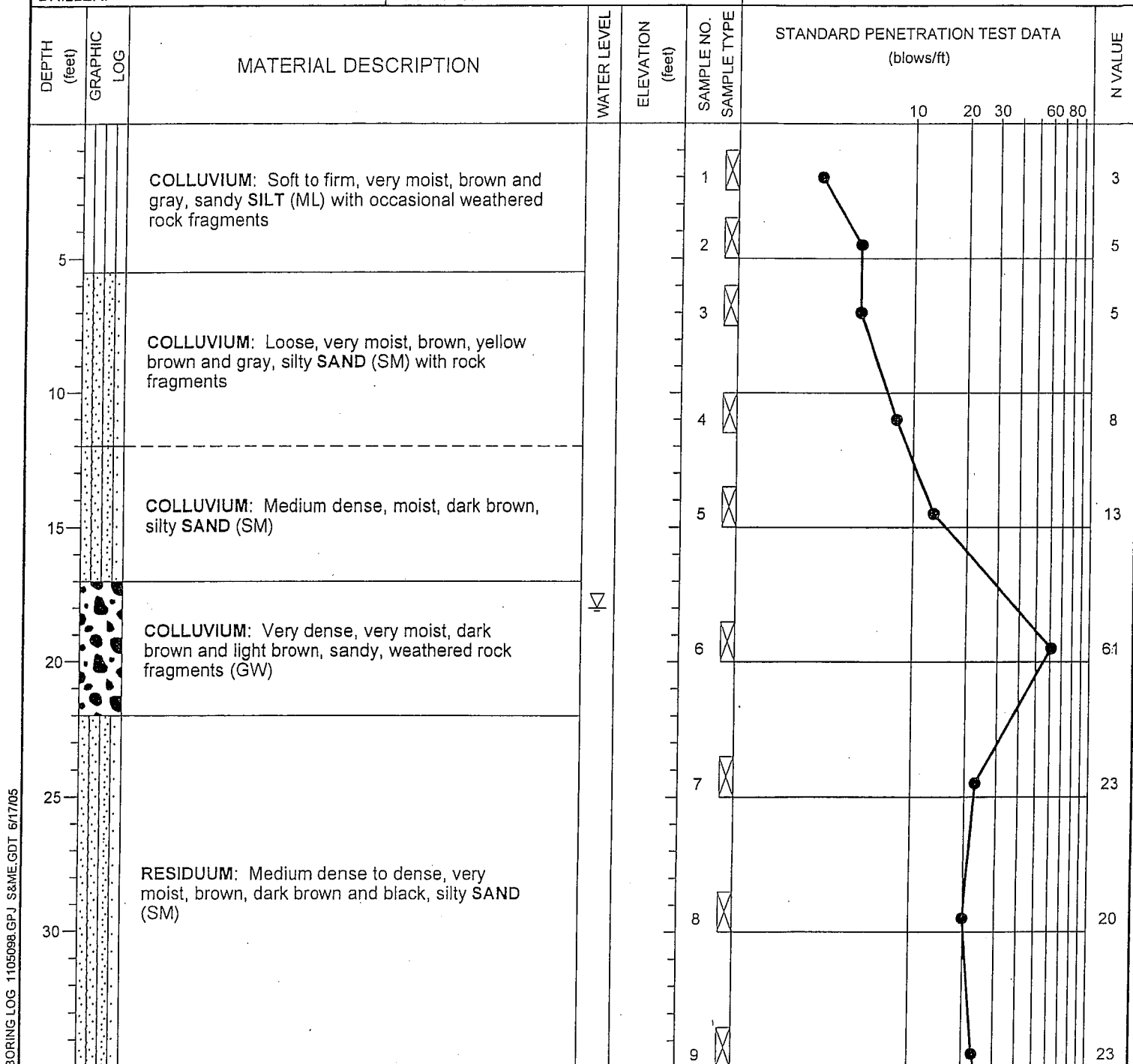
DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO. SAMPLE TYPE	STANDARD PENETRATION TEST DATA (blows/ft)	N VALUE
						10 20 30 60 80	
0		RESIDUUM: Dense, moist, tan brown, silty SAND (SM)			1		31
5		RESIDUUM: Loose, moist, gray and white, silty SAND (SM) with rock fragments			2		9
10					3		4
15		RESIDUUM: Soft to stiff, wet, micaceous, gray brown to tan brown and black, fine sandy SILT (ML)			4		12
20					5		13
25					6		14
30		RESIDUUM: Medium dense, wet, micaceous, gray brown and white, fine silty SAND (SM)			7		16
35					8		22
40					9		20
45		RESIDUUM: Hard, wet, brown and gray, fine sandy SILT (ML)			10		37
50		PARTIALLY WEATHERED ROCK: Sampled as hard, wet, brown and gray, fine sandy SILT			11		49
		Boring Terminated @ 50.0'			12		50/3.5

NOTES:

- THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.
- BORING, SAMPLING AND PENETRATION TEST DATA IN GENERAL ACCORDANCE WITH ASTM D-1586.
- STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.
- WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.

DATE DRILLED: 4/19/05	ELEVATION:
DRILLING METHOD: 2 1/2" H.S.A.	BORING DEPTH: 50.0
LOGGED BY: J. JACOBSON	WATER LEVEL: 18.0' @ TOB
DRILLER:	DRILL RIG: Mobile B-56

NOTES:



NOTES:

- THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.
- BORING, SAMPLING AND PENETRATION TEST DATA IN GENERAL ACCORDANCE WITH ASTM D-1586.
- STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.
- WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.

PROJECT: CRAGGY GARDENS - BLUE RIDGE PARKWAY
ASHEVILLE, NORTH CAROLINA
S&ME Project No. 1411-05-098

BORING LOG B-3

DATE DRILLED: 4/19/05

ELEVATION:

NOTES:

DRILLING METHOD: 2 1/4" H.S.A.

BORING DEPTH: 50.0

LOGGED BY: J. JACOBSON

WATER LEVEL: 18.0' @ TOB

DRILLER:

DRILL RIG: Mobile B-56

DEPTH (feet)	GRAPHIC LOG	MATERIAL DESCRIPTION	WATER LEVEL	ELEVATION (feet)	SAMPLE NO. SAMPLE TYPE	STANDARD PENETRATION TEST DATA (blows/ft)					N VALUE
						10	20	30	60	80	
40		RESIDUUM: Medium dense to dense, very moist, brown, dark brown and black, silty SAND (SM) (continued)	HC		10						31
45					11						28
50		RESIDUUM: Dense, moist, white and brown, silty fine SAND (SM)			12						44
		Boring Terminated @ 50.0'									

NOTES:

1. THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.
2. BORING, SAMPLING AND PENETRATION TEST DATA IN GENERAL ACCORDANCE WITH ASTM D-1586.
3. STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.
4. WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.

Page 2 of 2



S&ME

ENGINEERING • TESTING
ENVIRONMENTAL SERVICES

PROJECT: CRAGGY GARDENS - BLUE RIDGE PARKWAY
ASHEVILLE, NORTH CAROLINA
S&ME Project No. 1411-05-098

BORING LOG B-4

DATE DRILLED: 4/18/05

ELEVATION:

NOTES:

DRILLING METHOD: 2 1/4" H.S.A.

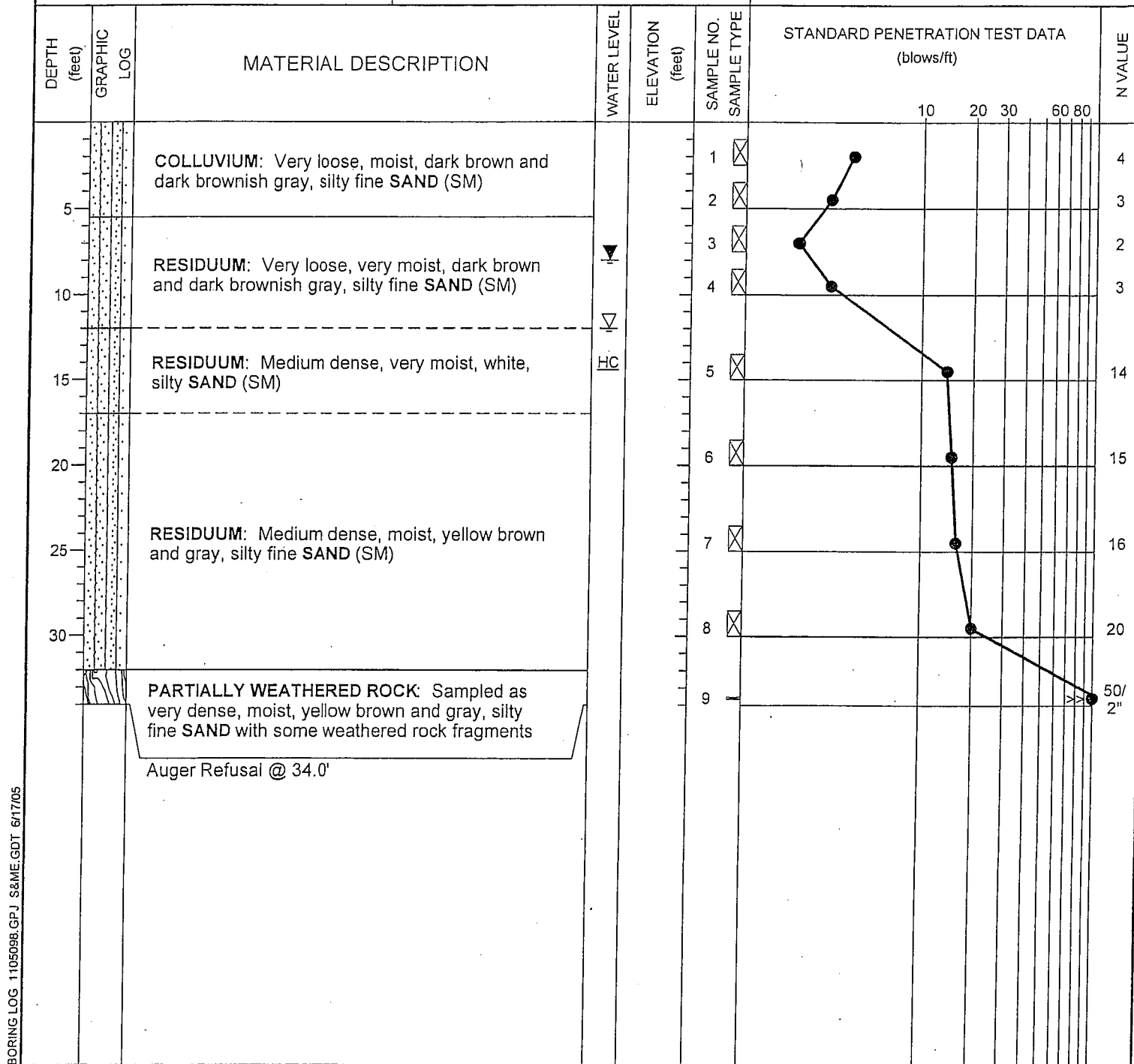
BORING DEPTH: 34.0

LOGGED BY: J. JACOBSON

WATER LEVEL: 8.0' @ 24 HOURS

DRILLER:

DRILL RIG: Mobile B-56



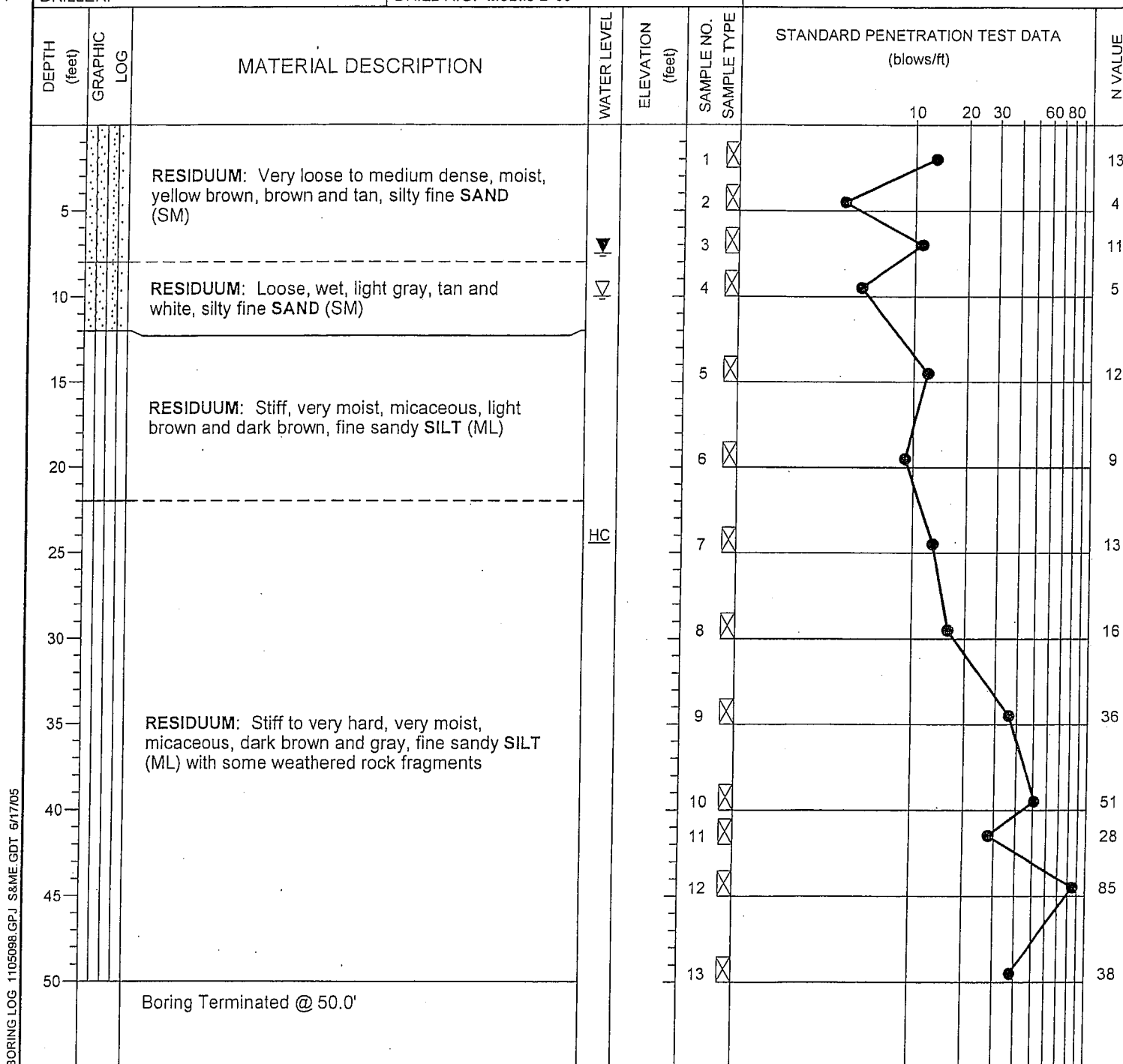
NOTES:

1. THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.
2. BORING, SAMPLING AND PENETRATION TEST DATA IN GENERAL ACCORDANCE WITH ASTM D-1586.
3. STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.
4. WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.

Page 1 of 1

DATE DRILLED: 4/17/05 ELEVATION:
DRILLING METHOD: 2 1/4" H.S.A. BORING DEPTH: 50.0
LOGGED BY: J. JACOBSON WATER LEVEL: 7.5' @ 24 HOURS
DRILLER: DRILL RIG: Mobile B-56

NOTES:



NOTES:

1. THIS LOG IS ONLY A PORTION OF A REPORT PREPARED FOR THE NAMED PROJECT AND MUST ONLY BE USED TOGETHER WITH THAT REPORT.
2. BORING, SAMPLING AND PENETRATION TEST DATA IN GENERAL ACCORDANCE WITH ASTM D-1586.
3. STRATIFICATION AND GROUNDWATER DEPTHS ARE NOT EXACT.
4. WATER LEVEL IS AT TIME OF EXPLORATION AND WILL VARY.

FIELD TESTING PROCEDURES

SOIL TEST BORINGS

All borings and sampling were conducted in accordance with ASTM D-1586-99 test method. Initially, the borings were advanced by either mechanically augering or wash boring through the overburden soils. When necessary, a heavy drilling fluid is used below the water table to stabilize the sides and bottom of the borehole. At regular intervals, soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-barrel or split-spoon sampler. The sampler was first seated 6 inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is designated as the "Standard Penetration Resistance" or N-value. The penetration resistance, when properly evaluated, can be correlated to consistency, relative density, strength and compressibility of the sampled soils.

WATER LEVEL READINGS

Water level readings are normally taken in conjunction with borings and are recorded on the Boring Logs following termination of drilling (designated by) ∇ and at a period of 24 hours following termination of drilling (designated by ∇). These readings indicate the approximate location of the hydrostatic water table at the time of our field exploration. The groundwater table may be dependent upon the amount of precipitation at the site during a particular period of time. Fluctuations in the water table should also be expected with variations in surface run-off, evaporation, construction activity and other factors.

Occasionally the boreholes sides will cave, preventing the water level readings from being obtained or trapping drilling water above the cave-in zone. In these instances, the hole cave-in depth (designated by HC) is measured and recorded on the Boring Logs. Water level readings taken during the field operations do not provide information on the long-term fluctuations of the water table. When this information is required, piezometers are installed to prevent the boreholes from caving.

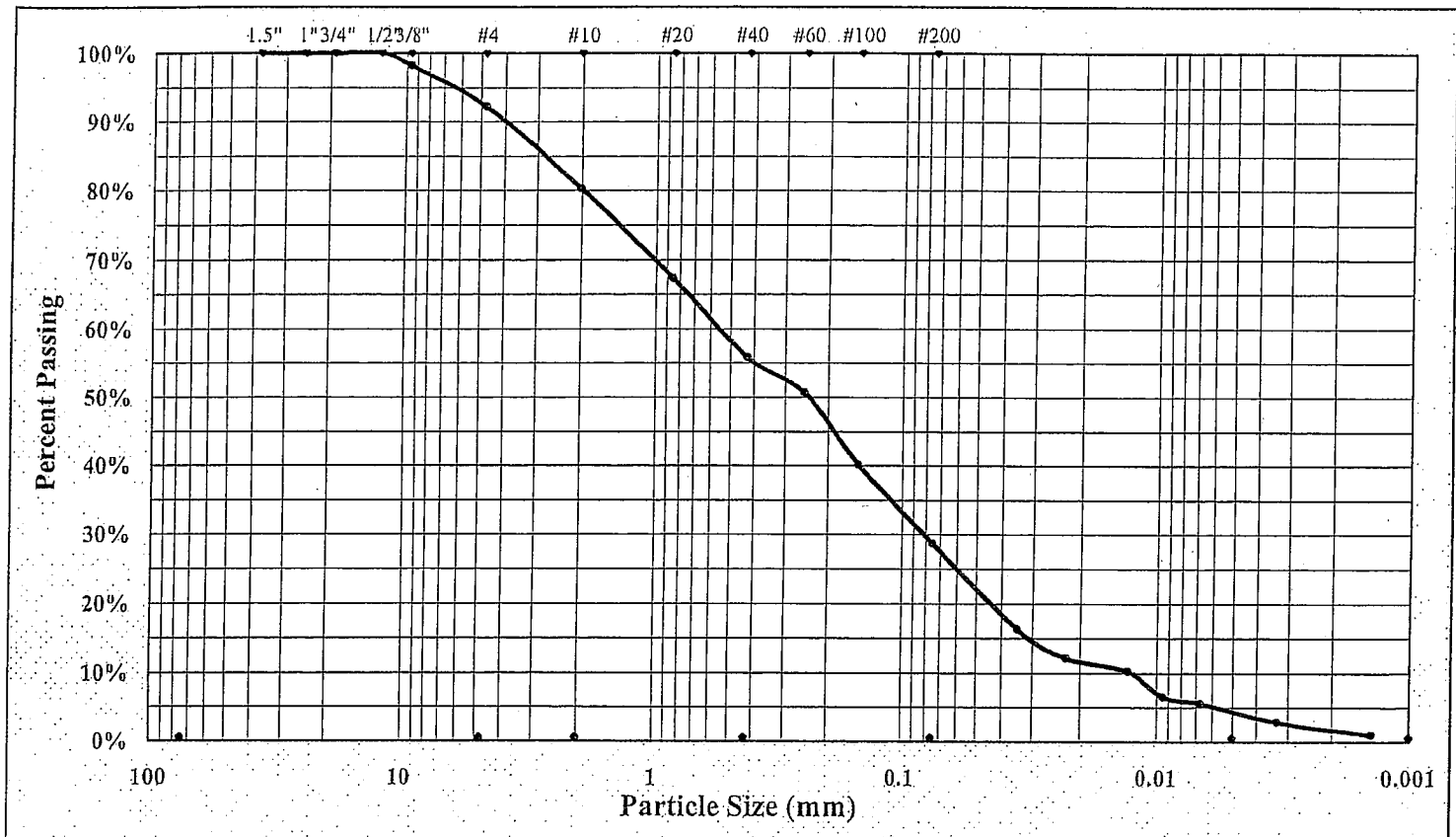


ASTM D 422

S&ME Project #: 1411-05-098
Project Name: CRAGGY GARDENS
Client Name: ARCADIS
Client Address:

Report Date: 05-19-05
Test Date(s): 05-17-05

Boring #:	B-2	Sample #:		Sample Date:	04-18-05
Location:		Offset:		Elevation:	Unknown
Sample Description:	GRAYISH BROWN SILTY SAND				



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and > 2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	1	Gravel	7.8%	Silt
Silt & Clay (% Passing #200)	28.6%	Sand	63.5%	Clay
Apparent Relative Density	2.670	Moisture Content		Colloids
Liquid Limit		Plastic Limit		Plastic Index

Description of Sand & Gravel Particles Rounded ☐ Angular ☐ Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A)	Length of Dispersion Period:	1 min.	Dispersing Agent:	Sodium Hexametaphosphate:	40 g./Liter
-----------------------------------	------------------------------	--------	-------------------	---------------------------	-------------

References: ASTM D 422: Particle Size Analysis of Soils

ASTM D 421: Dry Preparation of Soil Samples

ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils

ASTM D 854: Specific Gravity of Soils

ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Direct entry in this cell is allowed

Direct entry in this cell is allowed

Direct entry in this cell is allowed

Technical Responsibility:

Signature

Position

S&ME, INC.

44 Buck Shoals Rd., Unit C-3, Arden, NC 28704

ASTM D422 B2 1.0 to 2.5'

Particle Size Analysis of Soils

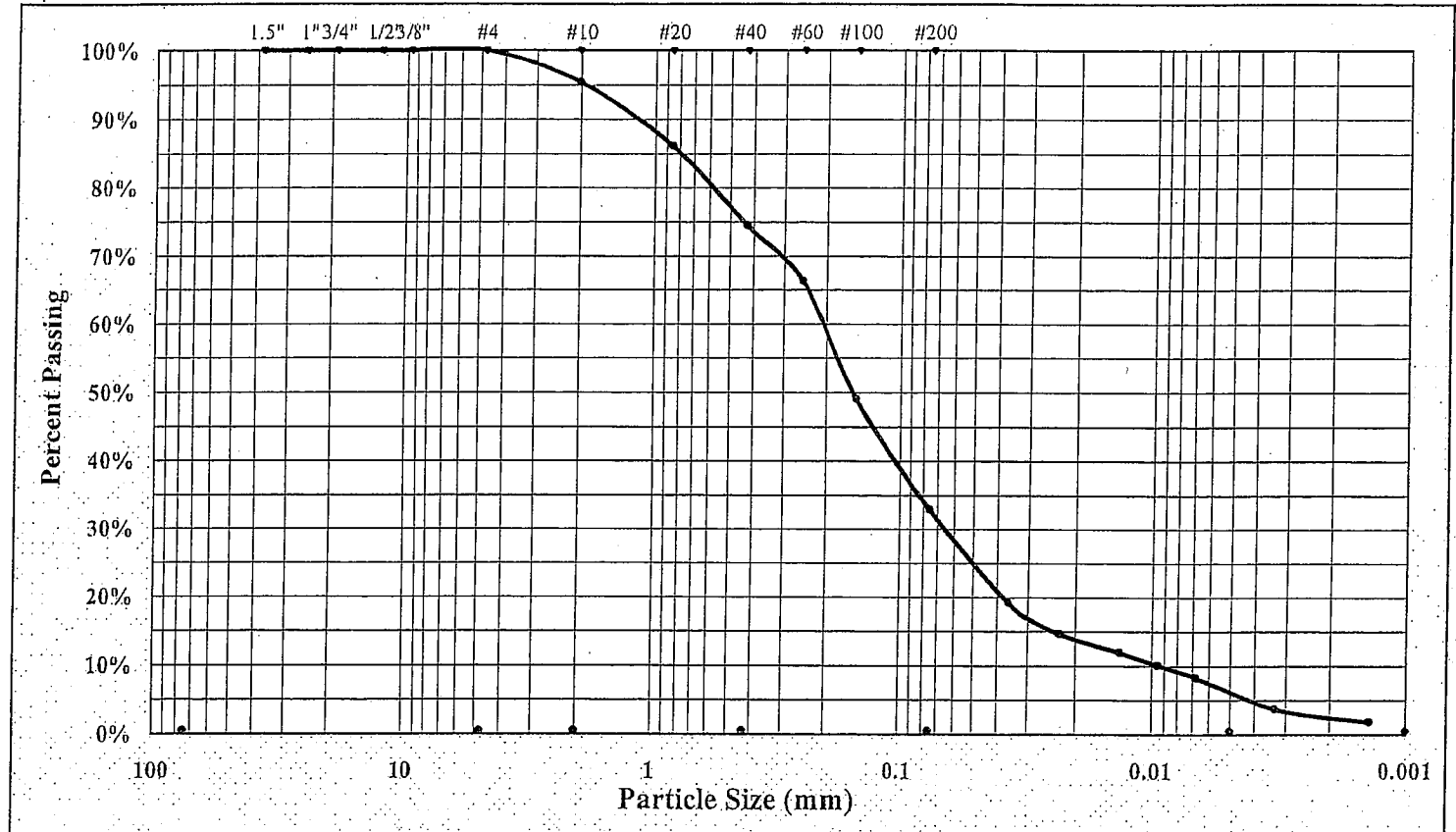


ASTM D 422

S&ME Project #: 1411-05-098
 Project Name: CRAGGY GARDENS
 Client Name: ARCADIS
 Client Address:

Report Date: 05-19-05
 Test Date(s): 05-17-05

Boring #: B-2 Sample #: Sample Date: 04-18-05
 Location: 6' TO 7.5' Offset: Elevation: Unknown
 Sample Description: GRAY BROWN SILTY SAND





Report Date: 05-19-05
Test Date(s): 05-17-05

The graph displays the particle size distribution of a material. The x-axis represents Particle Size in millimeters (mm) on a logarithmic scale, with major ticks at 100, 10, 1, 0.1, 0.01, and 0.001. The y-axis represents Percent Passing on a linear scale from 0% to 100% in 10% increments. The curve starts at 100% passing for particle sizes greater than 1 mm and drops sharply between 1 mm and 0.1 mm, reaching approximately 20% passing at 0.1 mm. The curve then levels off, approaching 0% passing for particle sizes smaller than 0.01 mm. The curve is labeled with sieve sizes: 1.5", 1" 3/4", 1" 23/8", #4, #10, #20, #40, #60, #100, and #200.

Particle Size (mm)	Sieve Size	Percent Passing (%)
100	1.5"	100
37.5	1" 3/4"	100
25	1" 23/8"	100
4.75	#4	100
2.0	#10	100
0.85	#20	85
0.425	#40	65
0.25	#60	55
0.15	#100	35
0.075	#200	20
0.0425	-	15
0.025	-	10
0.015	-	8
0.0075	-	5
0.00425	-	2
0.0025	-	1
0.0015	-	1
0.00075	-	0

ASTM D422 B4 3.5 to 5.0'

Particle Size Analysis of Soils

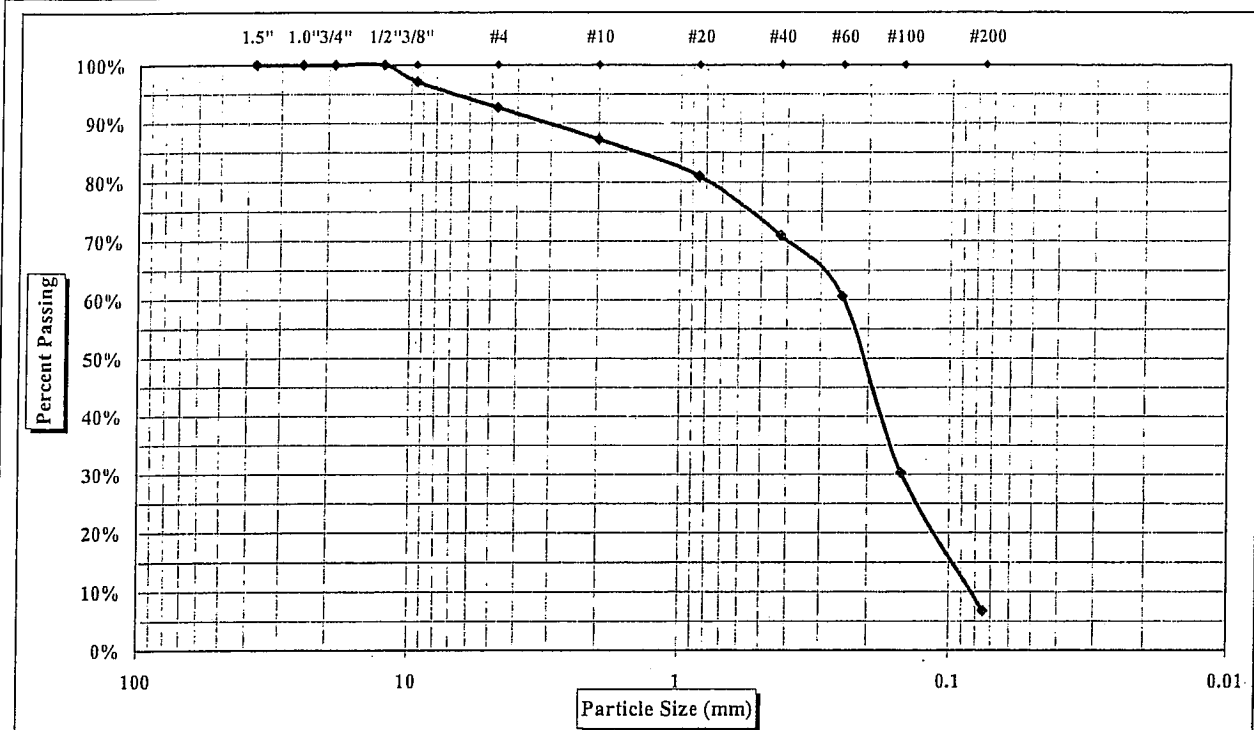
ASTM D 422



S&ME Project #: 1413-05-098
 Project Name: CRAGGY GARDENS
 Client Name: ARCADIS
 Client Address:

Report Date: 05/19/2005
 Test Date(s): 05/17/2005

Boring #: B-4 Sample #: Sample Date: April 18, 2005
 Location: 9.0' to 10.5' Offset: Elevation: Unknown
 Sample Description: DARK BROWN SILTY FINE SAND



Cobbles	< 300 mm (12") and > 75 mm (3")	Fine Sand	< 0.425 mm and > 0.075 mm (#200)
Gravel	< 75 mm and > 4.75 mm (#4)	Silt	< 0.075 and > 0.005 mm
Coarse Sand	< 4.75 mm and > 2.00 mm (#10)	Clay	< 0.005 mm
Medium Sand	< 2.00 mm and > 0.425 mm (#40)	Colloids	< 0.001 mm

Maximum Particle Size	3/8	Gravel	7%	Medium Sand	16%
Silt & Clay (% Passing #200)	6.7%	Coarse Sand	5%	Fine Sand	64%
Apparent Relative Density				Organic Content	
Liquid Limit	TNP	Plastic Limit	TNP	Plastic Index	TNP

Description of Sand & Gravel

Rounded ☐ Angular ☒ Hard & Durable ☐ Soft ☒ Weathered & Friable ☐

References: ASTM D 422: Particle Size Analysis of Soils *Hydrometer portion of test method not utilized.*
 ASTM D 421: Dry Preparation of Soil Samples
 ASTM D 4318: Liquid Limit, Plastic Limit, & Plastic Index of Soils
 ASTM D 2487: Classification of Soils for Engineering Purposes (Unified Soil Classification System)

Technical Responsibility:

Signature

Position



Report Date: 05-19-05
Test Date(s): 05-17-05

ASTM D422 B5 6.0 to 7.5'



ATTERBERG LIMITS

Job No: 1411-05-098

ASTM D: 4318

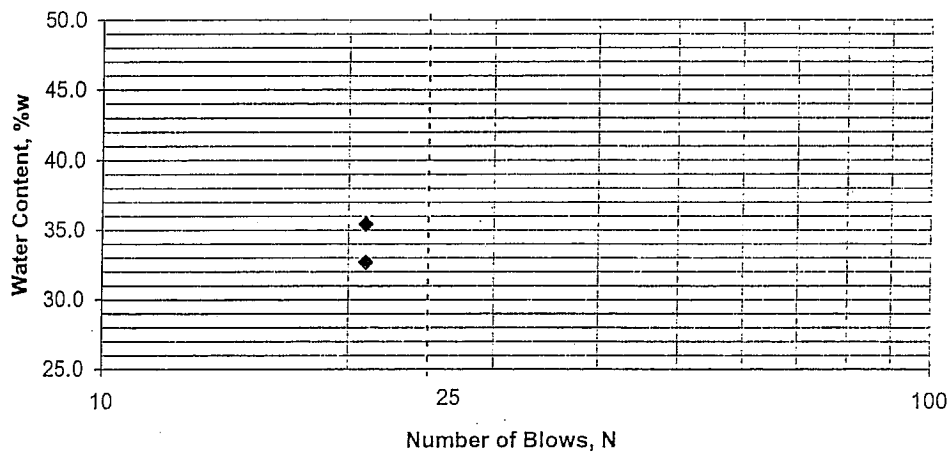
Job Name: CRAGGY GARDENS

Operator: MET

Sample No: B2 6.0' to 7.5'

Date: 05/18/05

LIQUID LIMIT DETERMINATION					
Tare No.	7	5			
Soil & Tare Wet Wt.	40.98	46.82			
Soil & Tare Dry Wt.	34.66	38.52			
Tare Wt.	15.29	15.09			
Moisture Content; %	32.7	35.4	#DIV/0!	#DIV/0!	#DIV/0!
No. of Blows; N	21	21			



PLASTIC LIMIT DETERMINATION					
Tare No.					
Soil & Tare Wet Wt.					
Soil & Tare Dry Wt.					
Tare Wt.					
Moisture Content; %	#DIV/0!		#DIV/0!		#DIV/0!
LL= 32 PL = NP PI = NP					



ATTERBERG LIMITS

Job No: 1411-05-098

ASTM D: 4318

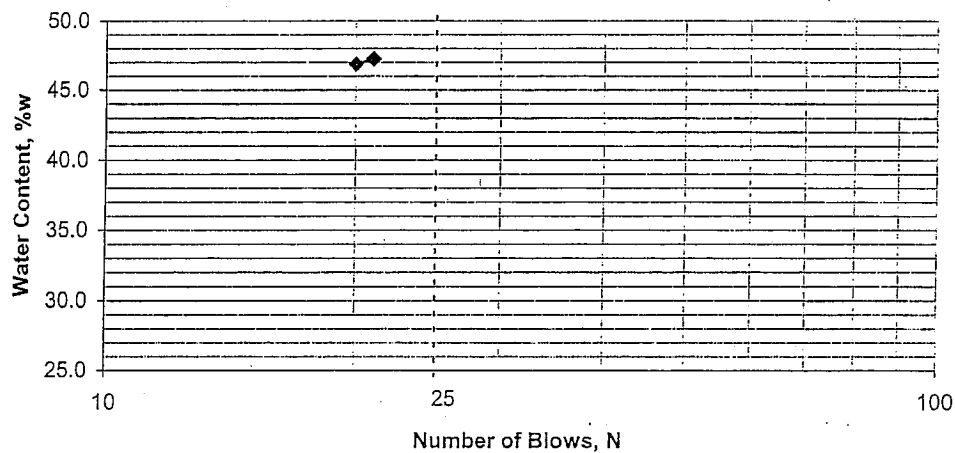
Job Name: CRAGGY GARDENS

Operator: MET

Sample No: B-3 4.0' to 5.5'

Date: 05/18/05

LIQUID LIMIT DETERMINATION					
Tare No.	3	1			
Soil & Tare Wet Wt.	44.06	45.80			
Soil & Tare Dry Wt.	34.84	36.13			
Tare Wt.	15.31	15.49			
Moisture Content; %	47.2	46.9	#DIV/0!	#DIV/0!	#DIV/0!
No. of Blows; N	21	20			



PLASTIC LIMIT DETERMINATION					
Tare No.					
Soil & Tare Wet Wt.					
Soil & Tare Dry Wt.					
Tare Wt.					
Moisture Content; %	#DIV/0!		#DIV/0!		#DIV/0!
LL= 46 PL = NP PI = NP					



ATTERBERG LIMITS

Job No: 1411-05-098

ASTM D: 4318

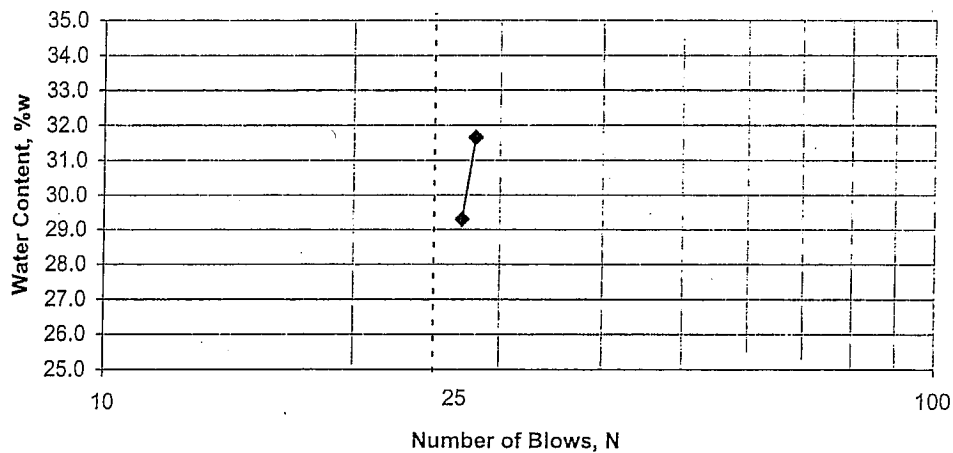
Job Name: CRAGGY GARDENS

Operator: MET

Sample No: B-5 3.5' to 5.0'

Date: 05/18/05

LIQUID LIMIT DETERMINATION					
Tare No.	11	4			
Soil & Tare Wet Wt.	49.08	51.66			
Soil & Tare Dry Wt.	41.50	42.93			
Tare Wt.	15.64	15.33			
Moisture Content; %	29.3	31.7	#DIV/0!	#DIV/0!	#DIV/0!
No. of Blows; N	27	28			



PLASTIC LIMIT DETERMINATION					
Tare No.					
Soil & Tare Wet Wt.					
Soil & Tare Dry Wt.					
Tare Wt.					
Moisture Content; %	#DIV/0!		#DIV/0!		#DIV/0!
LL= 31 PL = NP PI = NP					

MOISTURE CONTENT

Job No: 1411-05-098

ASTM D: 2216

Job Name: CRAGGY GARDENS

Operator: SDS

Samples:

Date: 5/11/2005

[illegible]

MOISTURE - DENSITY RELATIONSHIP

ASTM D 698-A



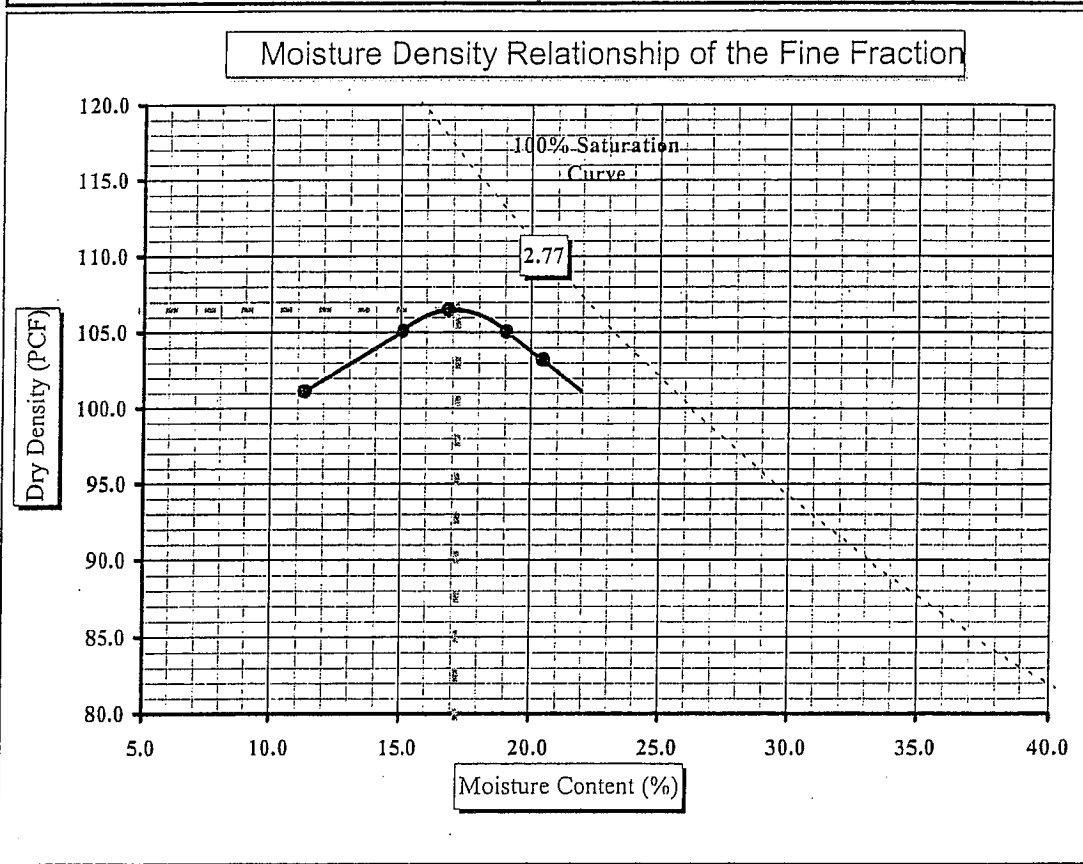
S&ME Project # : 1411-05-098
 Project Name : CRAGGY GARDENS
 Client : _____

Report Date : May 19, 2005
 Date Received : January 0, 1900

Log # : 733
 Sample Location : B-4
 Sample Description : BROWN SILTY SAND

Date Tested : May 16, 2005
 Depth : 1 TO 10

Maximum Dry Density	106.5 pcf	Oversize Corrected Maximum Dry Density (pcf)	NA	Soil Properties	
Optimum Moisture Content	17.2 %	Oversize Corrected Optimum Moisture Content (%)	NA	Moisture Content As Received	TNP



Liquid Limit	TNP
Plasticity Index	TNP
Group Symbol	TNP

Oversize Correction ASTM D 4718	
% Oversize On The 3/8"	NA
Bulk Specific Gravity	NA

Mechanical Hammer	
Manual Hammer	<input checked="" type="checkbox"/>
Moist Preparation	
Dry Preparation	<input checked="" type="checkbox"/>

Tested By: TP
 Reviewed By: 0

References:

ASTM D 698: Laboratory Compaction Characteristics of Soil Using Standard Effort
 ASTM D 2216: Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

Notes:

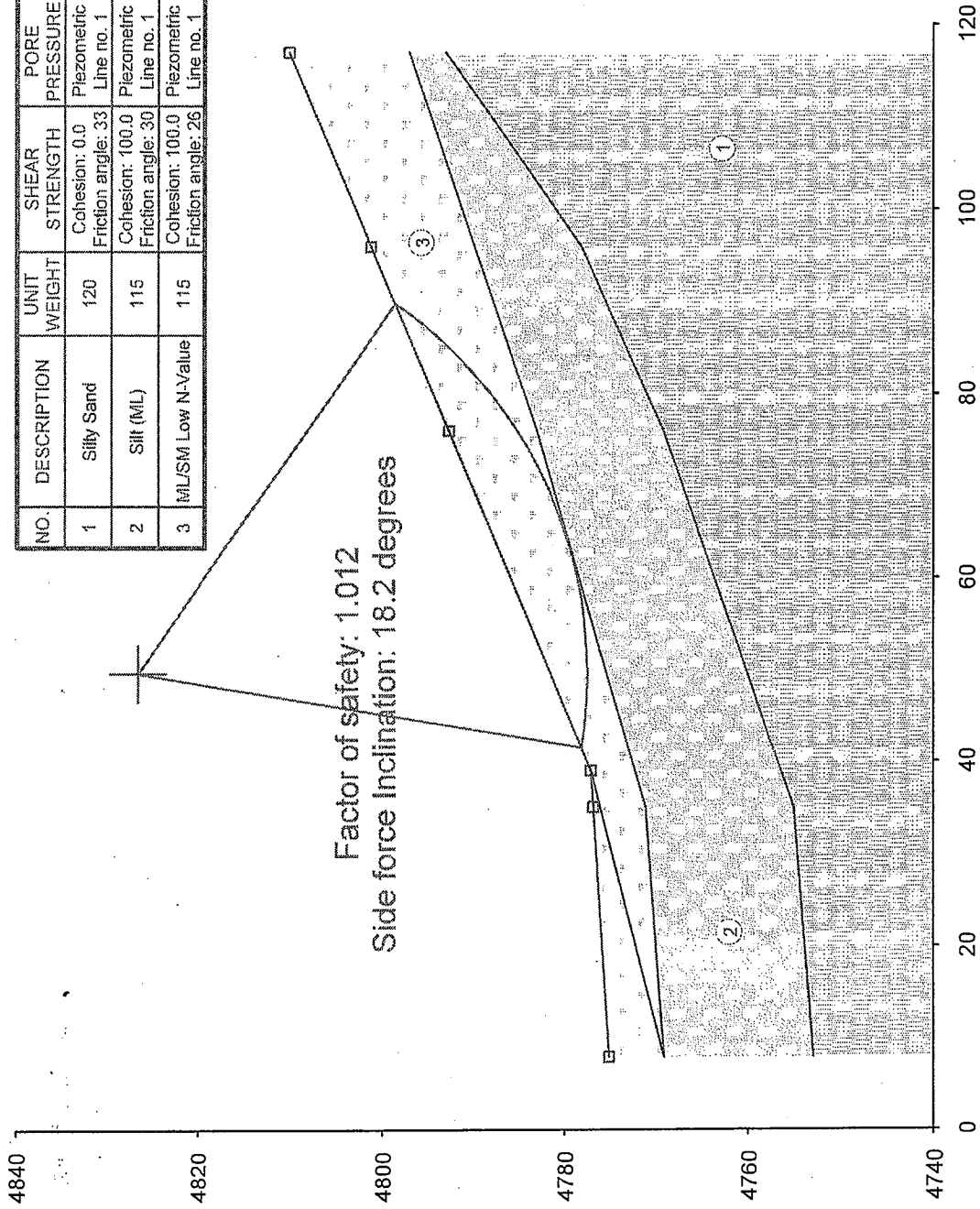
NA= Non-Applicable
 TBD = To Be Determined
 TNP = Test Not Performed

Appendix D

Stability and Seepage Analysis
Calculations

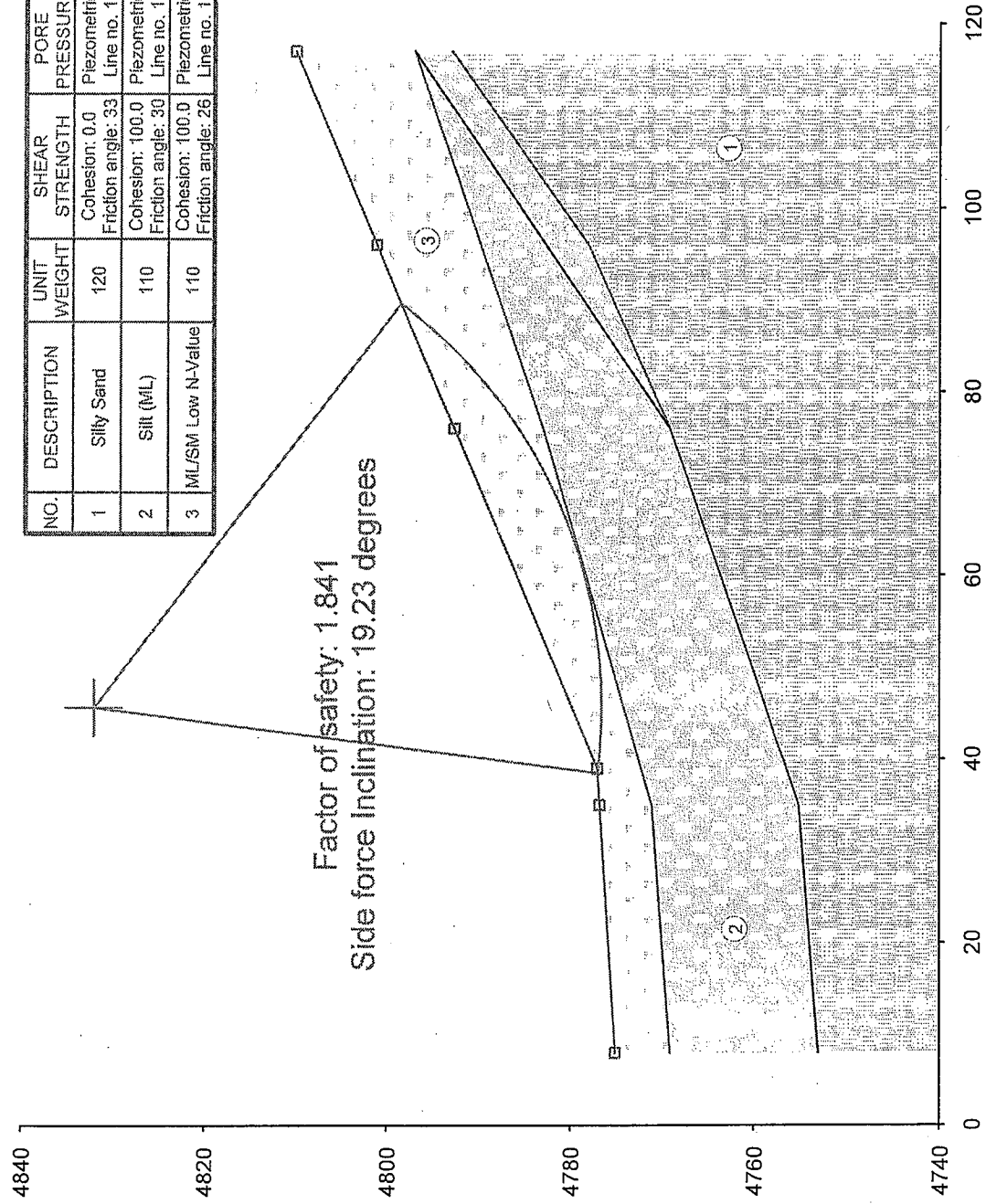
"Slide Investigation - Craggy Garden Picnic Access Area, Blue Ridge Parkway".

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Silty Sand	120	Cohesion: 0.0 Friction angle: 33	Piezometric Line no. 1
2	Silt (ML)	115	Cohesion: 100.0 Friction angle: 30	Piezometric Line no. 1
3	ML/SM Low N-Value	115	Cohesion: 100.0 Friction angle: 26	Piezometric Line no. 1

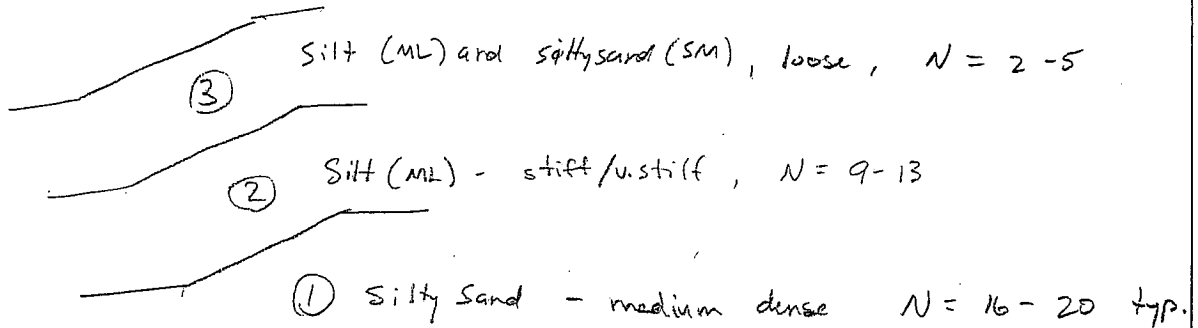


"Slide Investigation - Craggy Garden Picnic Access Area, Blue Ridge Parkway".

NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	Silty Sand	120	Cohesion: 0.0 Friction angle: 33	Piezometric Line no. 1
2	Silt (ML)	110	Cohesion: 100.0 Friction angle: 30	Piezometric Line no. 1
3	ML/SM Low N-value	110	Cohesion: 100.0 Friction angle: 26	Piezometric Line no. 1



Cross Section



Case 1 - Initial slope Failure

Assume that the slope fails when the groundwater surface is high \rightarrow Factor of safety (F.S.) is approximately 1.0 when slope fails. Limit top of failure circle to approx. location of known scarps.

- \rightarrow Groundwater surface defined as piezometric line at the ground surface. Slope is fully saturated.
- \rightarrow Strengths are assigned so that $F.S. \approx 1.0$ - Model is used as calibration for strength assignments

Case 2 - Underdrain installed

- \rightarrow groundwater is lowered to the bottom elevation of the drain
- \rightarrow strength remains unchanged from Case 1

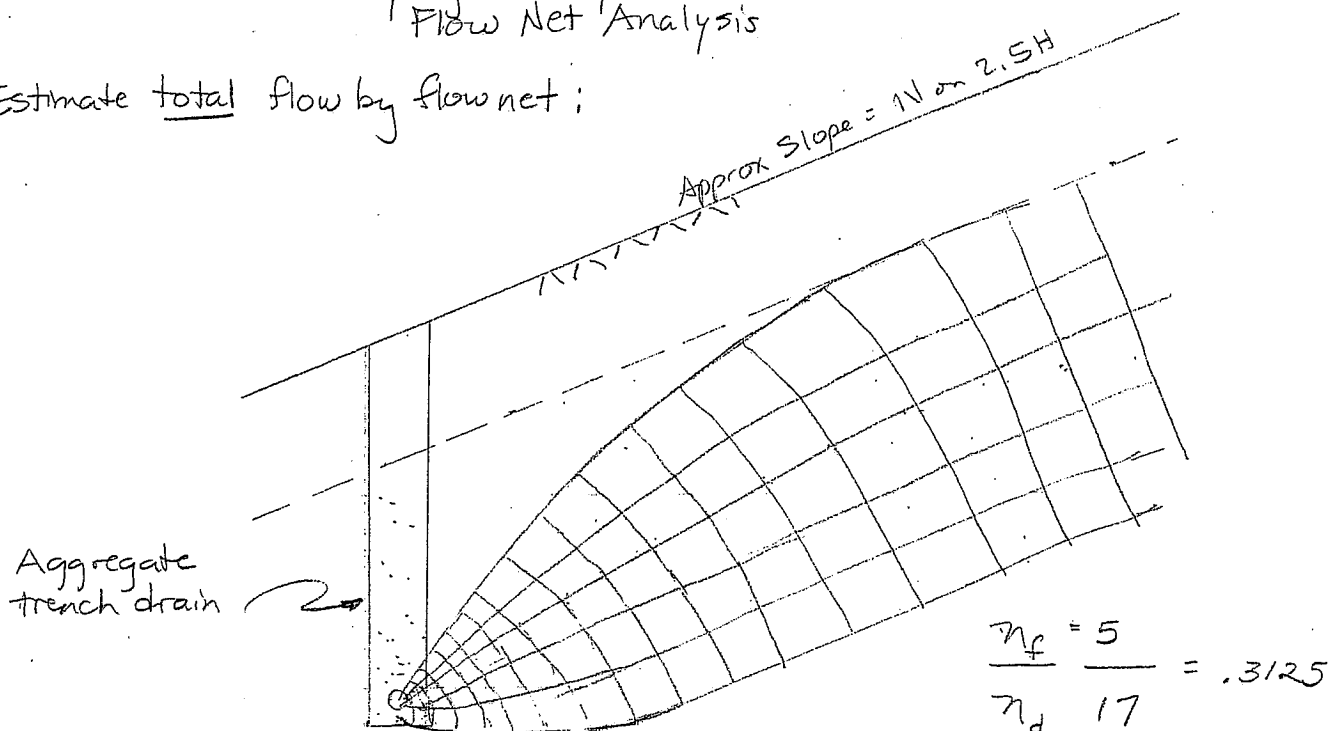
Results (UTEXAS4 Slope Stability Software)

Case 1: $FS = 1.012$

Case 2: $FS = 1.841$

Seepage Rough Estimate Flow Net Analysis

Estimate total flow by flow net:



$$q = kh \left(\frac{n_f}{n_d} \right) \quad \text{where } h = \text{head,} = 7'$$

$k = \text{permeability}$
 $= 10^{-3} \text{ cm/sec (conservative value)}$
 $= 2.835 \text{ ft/day}$

$$q = 2.835 \text{ ft/day (7') (.3125)}$$

$$= 6.2 \text{ ft}^2/\text{day or ft}^3/\text{day/ft length}$$

$$= 0.03 \text{ gpm/ft trench}$$

Assume total trench length = $\pm 400 \text{ l.f.,}$

$$Q = 0.03(400) = \underline{12} \text{ gpm (this represents a maximum expected flow)}$$